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BACTERIOLOGICAL SPECTRUM AND ANTIBIOTIC SUSCEPTIBILITY PATTERNS IN PATIENTS WITH ACUTE EXACERBATION OF COPD ADMITTED TO A TERTIARY CARE CENTRE IN RAJASTHAN

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ABSTRACT

Background: Acute exacerbations of Chronic Obstructive Pulmonary Disease (AECOPD) significantly contribute to morbidity, mortality, and healthcare burden, particularly in low- and middle-income countries. Bacterial infections are among the most common triggers, and increasing antimicrobial resistance complicates management. Regional bacteriological surveillance is essential for optimizing empirical antibiotic therapy.

Objective: To determine the bacteriological profile and antibiotic susceptibility patterns among patients hospitalized with AECOPD at a tertiary care center in Southern Rajasthan.

Methods: This hospital-based cross-sectional study included 83 clinically diagnosed AECOPD patients aged ≥45 years. Sputum samples fulfilling adequacy criteria (<10 squamous epithelial cells and >25 pus cells/LPF) were processed for Gram stain, aerobic culture, and antibiotic susceptibility testing using the Kirby–Bauer disc diffusion method as per CLSI guidelines. Demographic, clinical, and microbiological data were analyzed using SPSS v21. Categorical variables were compared using Chi-square test and continuous variables using Student's t-test, with $p<0.05$ considered statistically significant.

Results: Most patients were males (85.54%), within 61–65 years age group, and resided in rural areas (77.10%). Underweight BMI was observed in 44.58% of participants. Purulent or mucopurulent sputum predominated (75.90%). Pathogenic bacterial growth was detected in 43 (51.80%) samples, with Gram-negative bacilli accounting for 81.39% of isolates. The most commonly isolated pathogens were Pseudomonas aeruginosa (32.55%) and Klebsiella pneumoniae (23.25%), followed by Staphylococcus aureus (13.95%) and Haemophilus influenzae (11.62%). Antibiotic susceptibility

testing revealed highest sensitivity to Amikacin, Gentamicin, Piperacillin–Tazobactam, and Ciprofloxacin, while macrolides demonstrated high resistance.
Conclusion: Bacterial infection plays a major role in AECOPD, with Gram-negative organisms predominating. Emerging resistance to commonly prescribed antibiotics—especially macrolides—necessitates evidence-based empirical antibiotic selection. Local antibiograms, rational antimicrobial use, and preventive strategies including smoking cessation, vaccination, and nutritional support are vital to improving clinical outcomes and reducing resistance trends.

Keywords: AECOPD, sputum culture, antimicrobial resistance, Pseudomonas aeruginosa, COPD exacerbation, antibiotic susceptibility.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous and progressive respiratory disorder characterized by persistent airflow limitation associated with structural abnormalities of the airways and alveoli. The clinical presentation typically includes chronic cough, dyspnea, sputum production, and recurrent exacerbations attributable to chronic bronchitis, bronchiolitis, and emphysematous changes in the lungs [1]. COPD is considered a spectrum disorder with chronic bronchitis and emphysema representing two ends, although most patients demonstrate overlapping features [1].

The etiopathogenesis of COPD is multifactorial and reflects the interplay of genetic susceptibility, environmental exposure, and aging physiology, summarized under the concept of GETomics—Gene (G), Environment (E), and Time (T) [1]. Tobacco smoking remains the leading modifiable risk factor globally, including passive exposure, while indoor air pollution from biomass fuel combustion, occupational dust, fumes, and recurrent childhood respiratory infections contribute a substantial burden, particularly in developing countries [1,2]. Among genetic determinants, alpha-1 antitrypsin deficiency caused by mutations of the SERPINA1 gene is the most established hereditary risk associated with increased susceptibility to COPD [1].

The diagnosis of COPD is confirmed through spirometry demonstrating a post-bronchodilator FEV1/FVC ratio <0.70, which reflects persistent airflow limitation and distinguishes the condition from reversible obstructive airway diseases [1,3]. In recent years, terms such as “Pre-COPD” and “Preserved Ratio with Impaired Spirometry (PRISm)” have been introduced to describe individuals with structural or physiological abnormalities without classic airflow obstruction, highlighting disease continuum and emphasizing early identification [1].

COPD poses a significant global public health burden and ranks among the leading causes of morbidity and mortality. According to GOLD 2024 estimates, the global prevalence of COPD is approximately 10.3% with increasing trends attributed to aging populations and ongoing exposure to risk factors [1]. As per WHO projections, COPD is expected to become the third leading cause of death worldwide by 2030, with low- and middle-income countries disproportionately affected. India contributes over 20% of global COPD mortality, with an estimated 556,000 deaths annually, ranking among the highest worldwide [3-5]. In addition to health impacts, COPD imposes a heavy socioeconomic burden through direct healthcare expenditures and indirect losses in productivity, disability-adjusted life years (DALYs), and caregiver strain. For instance, economic burden attributable to COPD in the United States was approximately $49.9 billion in 2010 alone, demonstrating global scale implications [6].

The natural course of COPD is punctuated by acute exacerbations that represent episodes of acute clinical deterioration characterized by increased cough, sputum volume and purulence, and dyspnea requiring therapeutic escalation [1,7]. Exacerbations are critical events in disease course as they accelerate decline in lung function, negatively affect quality of life, increase hospitalization, and are associated with substantial mortality risk [1,6]. While the underlying inflammatory process in COPD is chronic and progressive, acute inflammatory surges triggered by respiratory infections or

environmental insults result in exacerbations marked by worsening airflow limitation, systemic inflammation, mucus hypersecretion, and gas trapping [8-10].

According to standardized definitions, an exacerbation is an acute event lasting less than 14 days, accompanied by increased breathlessness, cough, and/or sputum abnormality, often with tachypnea or tachycardia, and triggered by infection or environmental exposure [1]. Classification of exacerbations into mild, moderate, and severe is based on symptom severity, need for pharmacological intervention, and requirement for hospitalization, oxygen supplementation, or ventilatory support [1].

Respiratory infections, particularly viral pathogens, are major triggers of exacerbations. However, bacterial infections contribute significantly, especially in cases with markedly purulent sputum, and account for more than 40% of exacerbations in India [2,11]. The most frequently isolated bacteria associated with infective exacerbations include Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter species. Less commonly, organisms such as Enterobacter, Chlamydia pneumoniae, and methicillin-resistant Staphylococcus aureus (MRSA) have also been implicated [2,7,12].

The presence of chronic airway colonization complicates interpretation of microbial culture results. However, predominant bacterial growth and correlation with Gram stain findings remain helpful tools in differentiating colonization from pathogenic infection [11]. Evidence suggests that bacterial load increases significantly during exacerbations compared with stable disease states, supporting microbial roles in pathogenic flare-ups [4].

Antibiotic therapy forms a major part of exacerbation management, especially in cases with moderate to severe symptoms or purulent sputum, with more than 90% of AECOPD patients receiving antimicrobial treatment [7]. However, inappropriate or empirical use contributes to antimicrobial resistance (AMR), a growing public health concern. Therefore, regional bacteriological profiling and periodic surveillance of antimicrobial susceptibility patterns are essential to inform empirical antibiotic policies, optimize treatment outcomes, minimize treatment failures, and prevent emergence of resistant strains [8,12].

Existing literature suggests geographical variations in microbial etiology and resistance trends. Most available data are derived from Western nations, while limited information is available from South Asian populations, particularly from Southern Rajasthan where environmental risk exposures differ significantly [6,13]. Lack of microbiology infrastructure at peripheral healthcare facilities further amplifies the need for regional evidence to guide therapeutic practice.

Given this context, the present study aims to determine the aerobic bacterial profile and antibiotic sensitivity patterns among patients admitted with acute exacerbation of COPD at RNT Medical College, Udaipur. Understanding local pathogen distribution and resistance trends will support early initiation of appropriate antimicrobial therapy, reduce disease burden, prevent complications, and improve clinical outcomes.

METHODOLOGY

Study Design and Setting: This study was designed as a hospital-based cross-sectional investigation conducted in the Department of Respiratory Medicine at a tertiary care center in Southern Rajasthan.

Study Period: The study duration was 4 months (June 2025 to September 2025)

Study Population and Sampling Technique: Participants were enrolled consecutively from inpatient departments after applying eligibility criteria. Written informed consent was obtained prior to inclusion. Patients were classified as frequent (≥2 exacerbations/year) or non-frequent exacerbators (<2 exacerbations/year) based on GOLD definitions. The BODE index was calculated for all patients.

Inclusion Criteria

- Patients aged ≥45 years with clinical diagnosis of AECOPD according to GOLD 2023 criteria.
- Primary diagnosis of AECOPD at admission requiring hospitalization.
- Patients requiring ward or ICU care.

- Availability of an adequate sputum sample (<10 squamous epithelial cells and >25 pus cells per low-power field).
- Patients providing written informed consent.

Exclusion Criteria: Patients were excluded if they met any of the following criteria,
- Declined consent,
- Moribund condition or requiring invasive mechanical ventilation,
- Currently on antibiotics,
- Coexisting bronchiectasis, interstitial lung disease, pneumonia, or sequelae of pulmonary tuberculosis,
- Active or treated pulmonary tuberculosis, asthma, or malignancy,
- Significant comorbid cardiac conditions.

Sample Size Estimation
Sample size was calculated using the formula for single population proportion:
$n = (Z_{1-\alpha/2})^2 \times P(100–P) / d^2$

Where:
- $Z_1–\alpha/2 = 1.96$ (at 95% confidence interval),
- P = 30.7% based on prevalence from a previous study by Abi Abdallah G et al. [14],
- d = 10% allowable error.

Based on this calculation, a total of 83 patients diagnosed with acute exacerbation of COPD (AECOPD) were included.

Data Collection Procedure: A structured proforma was used to record demographic information, clinical presentation, comorbidities, symptom profile, smoking status, prior hospitalization, immunocompromised status, and radiological findings. Physical examination and systemic assessments were performed for all subjects.
Baseline investigations included complete blood count, renal and liver function tests, serum electrolytes, ESR, and high-sensitivity C-reactive protein. Chest radiographs (PA view) were performed routinely, and High-Resolution CT (HRCT) thorax was undertaken when indicated.
Sputum Sample Processing: Early morning deep-coughed sputum was collected following oral rinsing to minimize contamination. Samples were collected in sterile screw-capped containers and transported immediately to the microbiology laboratory, ensuring processing within two hours.
Specimens were evaluated for:
- Macroscopic appearance,
- Gram staining,
- Acid-fast bacilli smear,
- Aerobic culture and sensitivity testing.

Cultures were inoculated on blood agar, MacConkey agar, and chocolate agar and incubated at 37°C for 48–72 hours. Growth characteristics, Gram staining, and standard biochemical reactions were used for organism identification.

Antibiotic Susceptibility Testing: Antimicrobial susceptibility was performed using the Kirby–Bauer disk diffusion technique on Mueller-Hinton agar following Clinical Laboratory Standards Institute (CLSI) guidelines. Results were interpreted as:
- Susceptible,
- Intermediate, or
- Resistant, based on minimum inhibitory concentration correlation. Antibiotics tested included commonly available antimicrobial agents supplied through government formulary.

Statistical Analysis: Data entry was performed using Microsoft Excel (version 10) and statistical analysis was conducted using SPSS software (version 21). Quantitative variables were summarized as mean ±standard deviation (SD) and tested using Student's t-test. Categorical variables were analyzed using Chi-square test. A p-value <0.05 was considered statistically significant.
Ethical Considerations: The study adhered to ethical research principles, and informed consent was obtained prior to enrollment. No additional invasive procedure beyond routine care was performed. IEC Approval No.: RNT/Acad./Ethical/2025/694 dated 27.05.2025

RESULTS

A total of 83 patients admitted with acute exacerbation of COPD were included in the study. Most participants were males and belonged to the 61–65-year age group. A majority resided in rural areas, and underweight BMI was common. Table 1 shows the baseline demographic profile of study participants.

Table 1. Baseline Demographic Profile of Study Participants (n=83)

Variable	Category	Frequency	Percentage (%)
Age Group (years)	45–50	2	2.41
	51–55	9	10.84
	56–60	24	28.91
	61–65	32	38.55
	66–70	16	19.28
Gender	Male	71	85.54
	Female	12	14.46
Residence	Rural	64	77.10
	Urban	19	22.90
BMI Category	Underweight (≤18.4)	37	44.58
	Normal (18.5–24.9)	35	42.17
	Overweight (25–29.9)	9	10.84
	Obese (≥30)	2	2.41
Smoking Status	Smoker	29	34.93
	Non-Smoker	54	65.06

Most patients presented acutely with <14-day symptom duration, and dyspnea with productive cough was universal. Only about one-fourth had prior hospitalization or associated comorbidities. Table 2 shows the clinical and hospitalisation related profile.

Table 2. Clinical and Hospitalization-Related Profile

Variable	Category	Frequency	Percentage (%)
Previous admission (<15 days)	Yes	24	28.92
	No	59	71.08
Comorbidities	Hypertension	12	14.45
	Diabetes Mellitus	7	8.43
	CHF	3	3.61
	None	61	73.49
Duration of symptoms	<14 days	72	86.74
	>14 days	11	13.26
Symptoms	Dyspnea	83	100
	Cough with expectoration	83	100
	Fever	68	81.92
	Chest pain	55	66.26
	Hemoptysis	5	6.02

Purulent or mucopurulent sputum was the predominant finding, indicating likely bacterial infection. Table 3 shows the characteristics of expectoration.

Table 3. Characteristics of Expectoration		
Appearance	**Frequency**	**Percentage (%)**
Purulent/Mucopurulent	63	75.90
Mucoid	48	57.83
Foul smelling	18	21.69
Blood mixed	5	6.02

Pathogenic growth was identified in slightly more than half of sputum samples, with Gram-negative bacilli dominating the isolates. Table 4 shows the pattern of sputum culture and gram stain.

Table 4. Sputum Culture and Gram-Stain Pattern			
Laboratory Finding	**Frequency**	**Frequency**	**Percentage (%)**
Culture Result (n=83)	Pathogenic growth	43	51.81
	Normal flora	40	48.19
Gram Stain among culture-positive cases (n=43)	Gram-Negative Bacilli	35	81.39
	Gram-Positive Cocci	8	18.61

Pseudomonas aeruginosa was the most frequently isolated organism, followed by Klebsiella pneumoniae. The distribution of isolated organisms is shown in table 5.

Table 5. Distribution of Isolated Organisms (n=43)		
Organism Isolated	**Frequency**	**Percentage (%)**
Pseudomonas aeruginosa	14	32.55
Klebsiella pneumoniae	10	23.25
Staphylococcus aureus (MSSA+MRSA)	6	13.95
Haemophilus influenzae	5	11.62
Escherichia coli	4	9.30
Pseudomonas + Klebsiella (mixed)	2	4.65
Acinetobacter baumannii	1	2.32
Streptococcus pneumoniae	1	2.32

Amikacin, Gentamicin, Piperacillin-Tazobactam, and Ciprofloxacin demonstrated the highest sensitivity across isolates, while macrolides showed high resistance. Table 6 shows the antibiotic sensitivity profile and pattern of bacterial isolates.

Table 6. Antibiotic sensitivity profile of bacterial isolates							
Antibiotic	**Bacterial isolates (showing only Sensitivity %)**						
	PA (n=16)	**KP (n=12)**	**SA (n=6)**	**HI (n=5)**	**EC (n=4)**	**AB (n=1)**	**SP (n=2)**
Amikacin	68.75	66.67	100	100	87.50	100	100
Gentamicin	87.50	83.33	50	87.50	75	100	50
Ceftriaxone	50	50	50	12.50	31.25	0	50
Cefotaxime	43.75	31.25	62.50	50	16.67	0	50
Ceftazidime	62.50	50	25	66.67	16.67	0	66.67

Table 6. Antibiotic sensitivity profile of bacterial isolates							
Cefepime	6.25	12.50	0	16.67	16.67	0	16.67
Tetracycline	12.50	37.50	12.50	50	66.67	0	50
Doxycycline	6.25	25	83.33	25	25	100	16.67
Ampicillin	25	6.25	25	50	16.67	0	50
Amoxicillin–clavulanate	25	12.50	33.33	12.50	50	0	33.33
Piperacillin–tazobactam	81.25	66.67	33.33	37.50	6.25	100	33.33
Cefoperazone–sulbactam	68.75	50	16.67	50	18.75	0	16.67
Norfloxacin	25	12.50	16.67	37.50	33.33	0	16.67
Ciprofloxacin	75	83.33	33.33	62.50	37.50	100	33.33
Levofloxacin	37.50	66.67	33.33	62.50	75	100	33.33
Moxifloxacin	18.75	6.25	16.67	12.50	33.33	0	16.67
Erythromycin	6.25	0	66.67	12.50	0	0	66.67
Azithromycin	12.50	0	50	0	16.67	100	50
Clindamycin	31.25	0	66.67	25	0	0	66.67
Meropenem	68.75	33.33	50	87.50	81.25	0	50
Faropenem	62.50	31.25	50	50	0	0	50
Ertapenem	12.50	25	0	12.50	16.67	—	0
Imipenem	62.50	62.50	0	62.50	33.33	100	0

PA: Pseudomonas aeruginosa; KP: Klebsiella pneumoniae; SA: Staphylococcus aureus; HI: Haemophilus influenzae; EC: Escherichia coli; AB: Acinetobacter baumannii; SP: Streptococcus pneumoniae;
Resistance % = 100 - sensitivity %; — indicates antibiotic not tested or not applicable;
Staphylococcus aureus includes both methicillin-sensitive (MSSA) and methicillin-resistant (MRSA) isolates.

More than half of the exacerbation cases showed bacterial etiology, dominated by gram-negative pathogens. The antimicrobial susceptibility profile suggests aminoglycosides and antipseudomonal agents remain effective, while macrolide resistance is high, supporting cautious empirical antibiotic selection.

DISCUSSION

The present study evaluated the bacteriological profile and antibiotic sensitivity patterns among patients admitted with acute exacerbation of COPD. A total of 83 patients were included, and more than half demonstrated pathogenic microbial growth on sputum culture, highlighting the role of infection as a major precipitating factor for exacerbations.

Most patients in the present study belonged to the age group of 61–65 years, with advancing age significantly associated with acute exacerbation episodes. Similar age-related clustering has been documented in earlier studies by Chawla K et al. [15], Selvi et al. [12], and Manoj Bardhan et al. [5], indicating that exacerbations predominantly occur in the elderly. Progressive lung function decline, decreased immunity, and accumulated comorbidities may explain this increased susceptibility.

COPD exacerbations were significantly more common in males, consistent with findings from Aparna Ramesh et al. [6], Shaila Jay Shah et al. [11], Mythri B A et al. [4], P. Sharma et al. [16], and Manoj

Bardhan et al. [5]. Higher tobacco exposure, occupational risk factors, and sociocultural barriers limiting women's healthcare access likely contribute to male predominance. As reported in the Global Adult Tobacco Survey, smoking remains substantially higher among males, supporting this trend.

A majority of participants in this study resided in rural areas, reflecting observations from Aparna Ramesh et al. [6] and S. Shalini et al. [3]. Biomass fuel exposure, delayed healthcare access, inadequate preventive measures, and socioeconomic challenges frequently reported in rural settings may contribute to higher disease burden.

More than 40% of patients were underweight in the present study, similar to findings by Aparna Ramesh et al. [6] and P. Sharma et al. [16]. Malnutrition and reduced muscle mass are known consequences of chronic respiratory disease and are associated with poor outcomes, increased susceptibility to infection, and reduced respiratory strength.

Although smoking was identified in approximately one-third of participants, the association with male predominance was evident. Similar patterns have been reported by Gauri Kulkarni et al. [17], Aparna Ramesh et al. [6], and Shaila Jay Shah et al. [11]. Continued smoking in COPD patients accelerates structural airway damage and increases the frequency and severity of exacerbations.

Approximately one-fourth of study subjects had a history of hospitalization for prior exacerbations, comparable with reports from KO FW et al. [13], L. Erkan et al. [18], and Shaila Jay Shah et al. [11]. A history of prior exacerbations is a well-recognized predictor of future exacerbation risk, indicating the importance of surveillance and preventive management strategies.

Among clinical findings, cough with expectoration and dyspnea were universal. Fever and chest pain were also common, consistent with the infective nature of exacerbations and supported by studies such as Gauri Kulkarni et al. [17] and Deepthi Babu et al. [19]. Purulent sputum was common and correlated with bacterial isolation, consistent with observations in earlier microbiological analyses by Arora et al. [20] and Abi Abdallah et al. [14].

Pathogenic organisms were identified in 51.80% of sputum samples, a rate comparable to cultures reported by Mythri B A et al. [4], Arora et al. [20], and Selvi et al. [12]. Gram-negative bacteria predominated significantly, similar to findings from R. Wilson et al. [21], P. Sharma et al. [16], and Anand Patel et al. [22]. Such predominance may reflect severe disease phenotype, chronic airway colonization, and recurrent empirical antibiotic exposure.

The most frequently isolated organism in the present study was Pseudomonas aeruginosa, followed by Klebsiella pneumoniae, findings consistent with observations reported by Chawla K et al. [15], Dr. Selvi et al. [12], Deepthi Babu et al. [19], and Abhishrut et al. [23]. In contrast, some studies reported Streptococcus pneumoniae as the predominant organism, highlighting geographical and environmental variations in microbial epidemiology [10,22].

Antibiotic susceptibility patterns demonstrated highest sensitivity to Amikacin, Gentamicin, Piperacillin-Tazobactam, and Ciprofloxacin, while macrolide resistance was consistently high across isolates. Similar trends of increasing resistance against commonly prescribed antibiotics were reported in studies by S. Shalini et al. [3], K.A. Sahana et al. [10], and Narayan Mood et al. [9]. The pattern reflects changing resistance dynamics and underscores the importance of local antibiograms to guide empirical therapy.

Overall, the findings demonstrate that acute exacerbation of COPD in this region is predominantly associated with gram-negative pathogens exhibiting variable drug resistance, and therefore selection of empirical treatment should be guided by local microbiological surveillance.

CONCLUSION

The present study highlights the significant role of bacterial infection in acute exacerbations of COPD, with more than half of sputum cultures yielding pathogenic organisms. Gram-negative bacteria, particularly Pseudomonas aeruginosa and Klebsiella pneumoniae, dominated the microbial profile, reflecting a shift from traditionally described community-acquired pathogens to more resistant hospital-associated strains. The antimicrobial susceptibility pattern showed highest sensitivity to aminoglycosides, antipseudomonal β-lactams, and fluoroquinolones, whereas macrolides

demonstrated consistently poor activity, suggesting limited usefulness as empirical therapy in this region. The demographic pattern revealed that elderly males from rural areas with low BMI and smoking exposure formed the majority of hospitalized cases, reinforcing known epidemiological risk factors. These findings emphasize the need for region-specific antibiotic policies, routine microbiological surveillance, and rational antibiotic use to prevent further emergence of multidrug-resistant organisms. Incorporating preventive strategies, smoking cessation, vaccination, and nutritional support may help reduce exacerbation frequency and improve long-term outcomes in COPD patients.

Declarations
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